



USNDP Work Plan for Fiscal Year 2016

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Introduction

The work plan described in this document has been developed to cover work to be done by the United States Nuclear Data Program (USNDP) during fiscal year 2016 that begins on October 1, 2015. Previously, **16 work plans** have been prepared for the data program covering fiscal years 2000 - 2015. This plan has been prepared in consultation with the members of the Coordinating Committee who represent the organizations participating in the program. Each Coordinating Committee member prepared a draft plan for his/her organization. Each contribution was integrated into a unified work plan. The draft plan was then circulated to the Coordinating Committee for comments and corrections before the final document was submitted to the Department of Energy.

As was done in previous years, the tasks proposed by the various organizations were reviewed internally according to the following criteria which were developed considering the mission and goals outlined in past review panel reports and oversight committee discussions, and in consultation with the DOE program manager.

1. A task should be consistent with USNDP mission statement and meet one of the four program priorities:
 - a) Compilation of experimental results and relevant information published in the literature
 - b) Evaluation of the nuclear structure and decay and nuclear reaction data including improvements of the evaluation methodology
 - c) Archival and dissemination of nuclear data to the user community
 - d) Addressing specific data needs and gaps in nuclear data through targeted experiments.
2. A task should be useful to at least one major user community
3. A task should not duplicate efforts within or outside the program

The plan is divided into six major components. Specific tasks have been assigned to them. They are as follows:

- I. NNDC Facility Operation
- II. Coordination
- III. Nuclear Physics Databases
- IV. Information Dissemination
- V. Nuclear Structure Physics
- VI. Nuclear Reaction Physics

The following section details the proposed work plan for FY2016, defining tasks, organizational responsibilities, and planned activities. Incorporated in the NNDC plan is a group of subcontracted external scientists, including nuclear structure evaluators and compilers.

The present Workplan was prepared for the **2016 Guidance** scenarios.

Table 1: Summary of the USNDP funding and metrics for FY2001- FY2014.

Fiscal Year	USNDP Funding	Change	Compilations	Evaluations	Dissemination (in thousands)	Reports	Papers
2001			7,139	334	667	21	25
2002	\$4,890K		6,159	300	799	23	40
2003	\$4,932K	+0.9%	4,975	260	966	27	40
2004	\$5,015K	+1.7%	6,241	276	1,212	35	36
2005	\$5,437K	+8.4%	6,623	422	1,642	74	59
2006	\$5,099K	-6.6%	4,936	318	1,863	47	60
2007	\$5,841K	+14.6%	5,355	366	2,239	40	56
2008	\$5,967K	+2.2%	5,104	385	2,996	48	72
2009	\$6,267K	+5.0%	4,047	400	3,294	26	61
2010	\$6,549K	+4.5%	4,662	395	2,843	27	83
2011	\$6,534K	-0.2%	4,662	479	3,252	29	96
2012	\$6,785K	+3.8%	5,221	209	3,013	22	90
2013	\$6,249K*	-7.5%	5,165	243	3,447	29	84
2014	\$7,031K*	+12.5%	3,788	166	3,411	7	107

*: Includes a \$500K Early Career Award to LANL.

The FY2014 budget shows a \$782K (12.5%) increase compare to the previous fiscal year. The main changes were that BNL received and additional \$495K with respect to the previous year and ORNL \$229K.

For FY2016 we expect that:

- Compilation and dissemination activities will be fully supported.
- Evaluation effort will continue a moderate decline, mostly due to the temporary decrease of the reaction evaluations in favor of evaluation methodology, which results from the need to improve physics contents of the evaluations that resulted in setting up international CIELO collaboration. In addition, CIELO evaluations for 16O, 56Fe, 239Pu are far more complex than average ENDF evaluations and are expected to take about three years to be completed.
- Training and mentoring of new ENSDF evaluators will continue but will be limited to Korean evaluators.
- Development of nuclear reaction codes will continue focusing on evaluation methodology (fission, prompt fission neutron spectra, inelastic scattering, angular distributions and covariances).
- Internationally coordinated activities related to the new XML format will be carried out with possible extension to all nuclear data libraries.

- Dissemination of the nuclear data will continue approximately on the same level but no major improvements will be undertaken.

The postdoc at ANL moved last year to Michigan State University working mainly on ENSDF evaluation and XUNDL compilations. An important organizational change in FY16 is the transfer of the XUNDL management to the NNDC. This additional responsibility will coincide with the budget issue that may require the NNDC to reduce the scientific staff by one FTE in FY16 stretching its resources to the limit. The NNDC will also lose one reaction postdoc.

We expect to establish a Nuclear Data Advisory Committee (NDAC), involving representatives from the major stakeholders across basic and applied nuclear physics, to critically assess current efforts and proposed activities. The first NDAC meeting is expected to take place in November 2016.

The priority nuclear data activities remain:

- Compilation of structure (NSR, XUNDL) and reaction data (EXFOR)
- Evaluation of structure and decay data (ENSDF)
- Evaluation of reaction data (ENDF)
- Development of nuclear theory codes in support of data evaluation
- Development and maintenance of evaluation related software, formats and manuals
- Data archival and dissemination

I. NNDC Facility Operation

A. Management

This task includes planning, budgeting, personnel, interaction with BNL management, and interaction with funding authorities.

B. Library

NNDC maintains an archival collection of low- and intermediate-energy nuclear physics publications. This library supports the NNDC compilation activities and the U.S. nuclear reaction and nuclear structure data evaluation and international nuclear structure evaluation effort.

C. Computer Operation

The NNDC operates several servers running Red Hat Enterprise Linux in support of its compilation, evaluation, database maintenance, and information dissemination functions. These include two database servers, two Web servers, the GForge server and the recently added ADVANCE system server for nuclear data Quality Assurance and automatic posting of the results on the NNDC Web site. This task includes cyber security and software upgrades, hardware and software procurements, machine operations and internal user support for both the Linux and Windows platforms.

BNL planned activities
Ensure full compliance of NNDC computers with DOE cyber security requirements through regular scanning and prompt remediation of discovered vulnerabilities. to prevent suspension of its network access. Full compliance guarantees continuous availability of mission-critical NNDC Web services.
Provide prompt and effective technical computer support to NNDC staff, visitors and external collaborators in their use of NNDC computing resources.
Upgrade the suite of software running on the development/working server, the GForge server, the NNDC internal Web server, the ADVANCE server and the Linux cluster to meet NNDC's and the nuclear data community's growing computing requirements.

II. Coordination

A. National Coordination

National coordination is required for activities under the US Nuclear Data Program as well as Cross Section Evaluation Working Group. This is mostly performed by the National Nuclear Data Center, with contributions from other laboratories (USNDP Working Groups and Task Forces as well as CSWEG Committees).

ANL: Chair the Covariance Committee the Cross Section Evaluation Working Group.

ANL Planned Activities

Organize and chair the CSEWG Covariance Committee

BNL: Chair USNDP Coordinating Committee, chair Cross Section Evaluation Working Group, develop USNDP annual report and work plan, and maintain its USNDP website.

BNL planned activities

Prepare FY2017 work plan for USNDP.

Organize and chair CSEWG Meeting at BNL in November 2015.

Organize and chair USNDP Meeting at BNL in November 2015.

Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.

Maintain CSEWG and USNDP websites.

Organize mini-CSEWG meeting in the summer if needed.

LANL planned activities

Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2015.

Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2015.

LBNL: Serve as a member of the USNDP Coordinating Committee and chair the USNDP Nuclear Structure and Decay Data Working Group in addition to overseeing, coordinating, and directing the work of members of the Isotopes Project. The latter effort includes working with LBNL management, with other members of the USNDP, and with the program officers of the DOE.

LBNL planned activities

Work with the NNDC to improve the efficiency of nuclear structure data evaluation and better integrate US efforts with other nuclear data activities.

Coordinate EGAF Capture Gamma-ray Library evaluations with LLNL for preparation of ENDF format datasets and improved RIPL files.

Coordinate the West Coast collaboration to measure and evaluate neutron cross section measurements at the LBNL Cyclotron, UC Berkeley Department of Nuclear Engineering, and National Ignition Facility neutron facilities.

LLNL: Chair the Task Force on Nuclear Data Needs for Homeland Security of the Cross Section Evaluation Working Group.

LLNL planned activities

Organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.

ORNL: Chair the Astrophysics Task Force, and help facilitate and coordinate nuclear astrophysics data work at different labs to advance USNDP goals; provide leadership in planning future activities in nuclear data for nuclear astrophysics

ORNL planned activities

Communicate current efforts and future plans with researchers in nuclear astrophysics and nuclear astrophysics data.

Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data and in "town meetings", community meetings, and summer schools.

Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.

Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, and with other funding agencies.

B. International Coordination

ANL: Represent the ANL in IAEA-sponsored Nuclear Structure and Decay Data Network (NSDD) and Decay Data Evaluation Project. Participate in IAEA-sponsored coordinated research programs (CRP) and training workshops.

ANL planned activities

Participate in the IAEA Coordinated Research Project on "Nuclear data for charged-particle monitor reactions and medical isotope production"

Host several international visitors to ANL to collaborate on nuclear data research projects

BNL: Represent the United States in IAEA-sponsored Nuclear Reaction Data Center Network (NRDC) and Nuclear Structure and Decay Data Network (NSDD). The NNDC center head is the U.S. member and chairman of the IAEA's International Nuclear Data Committee (INDC), the lead US member of the NEA Working Party on International Evaluation Cooperation (WPEC) in his position as chair of CSEWG. Many of the NNDC staff participates in IAEA and NEA sponsored activities such as Workshops and Technical Meetings and Subgroups.

BNL planned activities

Participate in the IAEA-sponsored NRDC meeting in FY2016.

Participate in NEA WPEC annual meeting in FY2016.

Participate in IAEA organized network coordination meetings (NRDC, NSDD)

Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work (McMaster).

Participate in NEA-WPEC Subgroup 38 and 40 meetings.

Complete the 56Fe evaluation within the NEA-WPEC Subgroup 40 project.

LANL: Participate in and chair international nuclear reaction data collaborations. This insures that the U.S. benefits from breakthroughs around the world, and plays a leadership role in new developments. LANL staff members participate in NEA/WPEC committees on covariance data and international model code development cooperation. LANL will host visits by foreign scientists with international reputations to benefit from the exchange of information and ideas.

LANL planned activities

Participate in NEA-WPEC 2016 meeting

Participate in relevant IAEA coordinated meetings, such as reference input parameter library and nuclear cross section standards.

Co-organize and participate in the workshop on compound nucleus and related topics, CNR15, Oct 19-23, 2015, Tokyo

Make latest version of NJOY data processing code available to the international community.
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Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.
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Serve International Committee members of International Conference of Nuclear Data for Science and Technology, Belgium, Sept. 2016

LBNL: Participate in IAEA-sponsored training workshops, planning meetings and coordinated research programs on nuclear structure and decay data.

LBNL planned activities

Coordinate EGAF and RIPL evaluations with the IAEA.

Coordinate the development of a new continuum reaction/gamma-ray database with the IAEA and researchers at the Oslo Cyclotron Laboratory. Also coordinate to create a (n,n') database with the IAEA.
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Coordinate LBNL/Budapest/FRM-II/Julich TransActinide Nuclear Data Evaluation and Measurement (TANDEM) collaboration to measure actinide neutron cross sections.

TUNL: Represent TUNL at IAEA-sponsored at Nuclear Structure and Decay Data network (NSDD).

TUNL planned activities

Participate in the policy matters related to the NSDD network.
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Participate in NSDD/IAEA meetings

III. Nuclear Physics Databases

A. Nuclear Science References (NSR)

The NNDC is responsible for NSR, the bibliographic database for nuclear physics research. This task includes quality control, file update and maintenance, and file distribution to collaborators. Updates are done on a continuing basis. The preparation of NSR entries is given under Nuclear Structure Physics.

BNL planned activities

Distribute database to collaborators.

Provide international coordination of NSR compilations and activities.
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Database updates and maintenance.

Continue work on NNDC library publications digitization and Web access projects.
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Continue cooperation with NRDC network on the transfer of 6,000 EXFOR nuclear reaction references to NSR.

B. Experimental Nuclear Structure Data (XUNDL)

The NNDC is responsible for managing, maintaining and providing access to the XUNDL database. This database contains compilations (in ENSDF format) of recently published or completed level-structure data for high-spin and low-spin physics. The NNDC updates the database as new/ revised data sets are received from participating centers.

BNL planned activities

Weekly update of the database using input received from compilers.
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Distributed twice a year to the NSDD network.

Take over management of the XUNDL library.
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C. Evaluated Nuclear Structure Data File (ENSDF)

The NNDC is responsible for managing ENSDF, a database of evaluated experimental nuclear structure and decay data. The NNDC is responsible for format and content checking, preparation of manuscript, and quality control (review) of evaluations submitted for inclusion. The NNDC maintains the database, which includes database updates and distribution to collaborators. Corrections are implemented on a continuing basis.

BNL planned activities

Maintain ENSDF database, includes continuous updating.
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Process evaluations received from NSDD evaluators.
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Distribute ENSDF database to collaborators twice a year.
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D. Numerical Nuclear Data File (NuDat)

The NNDC is responsible for NuDat, which consists of a database and a suite of codes that access it, allowing web users to search for level and γ -ray properties extracted from ENSDF, ground and meta-stable state properties (Wallet Cards), atomic and nuclear radiations derived from ENSDF, and thermal neutron cross sections and resonance integrals. Additionally, NuDat contains an interactive Chart of Nuclides and interactive level schemes.

BNL planned activities

Update NuDat database as necessary, about 10 times a year.
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E. Neutron Reaction Data Bibliography (CINDA)

Through EXFOR compilation the NNDC continues to contribute to the CINDA database that contains references to nuclear reaction data in the published and unpublished literature. Since 2004, CINDA also contains bibliography information on charged-particle and photonuclear reactions. The database serves as an index to the data contained in the experimental database, EXFOR. The database is maintained by the Nuclear Data Section, IAEA Vienna.

BNL planned activities

Contribute to CINDA by compiling experimental cross-section data to the CSISRS and NSR databases.

F. Experimental Reaction Data File (EXFOR)

The NNDC is responsible for maintaining the EXFOR (CSISRS) database at BNL. This database contains experimental nuclear reaction data for incident energies below 1 GeV, including neutron-induced reactions and reactions with incident charged particles of mass $A \leq 12$. Many groups worldwide compile experimental data and send it to the central database in Vienna in the EXFOR format. Then, each is responsible to update its own database. The effort described here includes quality control, file update and data transfer activities. The NNDC database is updated, as compilations are exchanged and checked from the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

BNL planned activities

Update EXFOR database with compilations from cooperating centers (500 entries expected). The NNDC compilation work can be found under Nuclear Reaction Physics, chapter V of the present document.
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G. Evaluated Nuclear Data File (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The work is organized under the Cross Section Evaluation Working Group (CSEWG), coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident charged particles and photons are also included. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. New evaluations for the next release of the library are assembled, tested and made available to users through NNDC's Web servers and GForge collaboration server.

BNL planned activities

Maintain Linux/MySQL database system.

Maintain GForge/Subversion system for tracking development of the ENDF/B library.

Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).

Maintain and extend ADVANCE, the ENDF continuous integration system that continually checks for modification to the ENDF database then runs all available tests on the changed data files.
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H. Database Software Maintenance

This activity includes software bug fixes and enhancements for the six nuclear physics databases maintained by NNDC.

BNL planned activities

Fix bugs and develop enhancements for the six nuclear physics databases maintained by NNDC.

I. Database Systems Development

This activity includes updating database schema, maintenance of the existing content and addition of new data.

BNL planned activities

Upgrade the Linux/MySQL server software to fix bugs, provide new functionalities and improve the system's performance, security and reliability.
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Maintain the software for automatic replication of updates from the internal MySQL database server to the external to continuously comply with DOE cyber security requirements.

IV. Information Dissemination

The goal of the dissemination activities of the USNDP is to provide scientists and engineers with nuclear data from the USNDP-maintained nuclear databases in a variety of user-friendly formats and media.

A. Web Site Maintenance

The NNDC provides electronic access to the nuclear physics databases that it maintains on behalf of the USNDP as well as access to other nuclear physics information through its Web site. The NNDC Web services are powered by several multi-core servers running the Linux operating system and using the Apache, Tomcat and MySQL software. Other USNDP members also offer nuclear physics information through their websites.

ANL Planned Activities
Maintain and upgrade the ANL/NDM report series web site.
Maintain and upgrade Experimental Resources for Nuclear Data web site.
Maintain and upgrade ANL Nuclear Data Information web site.

BNL Planned Activities
Continued improvement to the ENSDF, NSR, NuDat and Sigma web interfaces.
Maintain web interfaces for ENDF and EXFOR databases.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users requests.
Continue to maintain the NNDC Web Services availability on the 99% and higher level.
Strictly follow all BNL and DOE cybersecurity rules and regulations during the Web application design, development and implementation. Address issues that arise during BNL scans.
Maintain GForge server powering NNDC collaboration services.
Begin modernization of the web site, following industry best practices.

ORNL Planned Activities
Expansion of features of our online software suite that supports the new mass evaluation effort, including new evaluation tools and dissemination capabilities; this activity is at risk of termination.

TUNL Planned Activities
Continue to improve the TUNL website and provide access to new information on $A = 3 - 20$ nuclei.
Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.
Continue to provide PDF and HTML documents for FAS reviews for the $A = 3 - 20$ series with the most current NNDC reference keys and with the direct hyperlink of reference with TUNL keys.
Continue to provide Energy Level Diagrams (in GIF, PDF and EPS/PS formats) to accompany the PDF and HTML documents for the most recent TUNL reviews and preliminary reports, and for the earlier FAS reviews.
Provide compiled and evaluated data on the decay of unstable ground states and on structure data from thermal neutron capture.
Provide compiled data related to the level parameters for $A = 3 - 20$ nuclei populated in proton- and alpha-particle-induced reactions.
Provide online access of TUNL dissertations collection.

B. Customer Services

This task accounts for the non-electronic services which the USNDP renders to customers. At the scientific staff level, this means direct assistance to users needing advice from nuclear data experts or advice on solving complex queries via electronic access to the database. The NNDC staff allocation at the support level is for maintaining a "help desk" and for administrative/clerical support of its customer services.

BNL Planned Activities
Provide technical support to nuclear data end-users as necessary.
Maintain Comments/Questions for all databases and web products.

C. Publications

The USNDP provides some paper publications as well as electronic access to the nuclear physics databases that it maintains. This includes the Nuclear Data Sheets published by Elsevier and various versions of the Nuclear Wallet Cards.

BNL Planned Activities
Prepare issues of Nuclear Data Sheets for publication.
Work on new version of Nuclear Wallet Cards.

Develop software for Nuclear Data Sheets publication (McMaster)

V. Nuclear Structure Physics

A. NSR Abstract Preparation

The literature search and preparation of KEYWORD abstracts for publications included in NSR require scientific expertise. BNL continues to have the overall responsibility for this database and since July 2013 is the only provider of the new entries to the NSR database.

BNL Planned Activities

Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them.
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Strengthen cooperation between NSR and EXFOR database compilation activities.

Analyze NSR database content for nuclear science development and authorship trends. Coordinate this effort with EXFOR database if necessary.
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B. Compilation of Experimental Structure Data

This activity involves compilation of recently published or completed experimental nuclear structure data for inclusion in XUNDL and other, more specific, databases. The XUNDL compilation is done by ANL, BNL, ORNL, and TUNL, while the NNDC is managing and maintaining the database.

ANL Planned Activities

Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.
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BNL Planned Activities

Compile new B(E2) experimental data. Continue work on a B(E2) evaluation project (in collaboration with McMaster and Central Michigan Universities). Publish a new evaluation for even-even nuclei, analysis of experimental data and Grodzin's fits.

Compile new double-beta decay experimental data. Evaluate precision of double-beta decay experimental half-lives and nuclear matrix elements.

Maintain, update and distribute XUNDL.
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Compile data sets (in ENSDF format) for current experimental nuclear structure publication. Scan the webpages of prominent journals in nuclear physics for new papers. Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database. Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data. Compile new mass measurements and submit data file to nuclearmasses.org webpage at ORNL. (McMaster)

ORNL Planned Activities

Compile XUNDL datasets as required.

TUNL Planned Activities

Compile datasets for current experimental nuclear structure data publications on A=2-20 nuclei for inclusion in the XUNDL database.

C. Data Evaluation for ENSDF

The USNDP evaluates nuclear structure and decay data for inclusion in the ENSDF database. This effort includes the critical analysis of all available experimental nuclear structure and radioactive decay data for a nuclide or a group of related nuclei to deduce recommended values from the measured data and prepare a file in ENSDF format that is the basis for publications in "Nuclear Data Sheets" and is used to update the contents of the USNDP nuclear structure and decay database, ENSDF. The US effort is supplemented by foreign contributions prepared under the auspices of the IAEA-sponsored international Nuclear Structure and Decay Data network.

ANL Planned Activities

Evaluate at least 1 mass chain from the ANL region of responsibility.

Review mass chain evaluations, as requested.
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Collaborate with scientists from other NSDD network centers on data evaluation projects.
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BNL Planned Activities

Continue mentoring new ENSDF evaluators.
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3.0 equivalent mass chains and the data for new nuclides (as mentioned below) will be evaluated. Mass chains will be reviewed as requested. Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides. Collaborate with a new center/evaluator as part of mentoring process, as needed (McMaster).

All evaluations submitted for publications are edited including checking for their format and physics content. Extensive changes are often made by NNDC staff.
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LBNL Planned Activities

Evaluate the equivalent of at least 3 mass chains (30 nuclides), including a minimum of one from the A=21-30 region. Emphasis will be placed on evaluating data of current interest to the nuclear structure and nuclear application communities.

Review mass-chain evaluations, as requested.
Train new compilers/evaluators.
Coordinate XUNDL evaluation efforts with UC Berkeley/LBNL/LLNL Nuclear Data Collaboration.

ORNL Planned Activities

3.0 equivalent mass chains and the data for new nuclides (as mentioned below) will be evaluated. Mass chains will be reviewed as requested.

TUNL Planned Activities

Evaluate about 1-2 A-chains per year for publication in Nuclear Data Sheets and inclusion in the ENSDF database.

Evaluate and update ENSDF for A=2-20 near drip-line nuclides, especially for first observations or when ENSDF has no previous data set.

Update various reaction data sets in ENSDF, such as for beta-decay and beta-delayed particle emission.

D. Ground and Metastable State Properties

The NNDC maintains a database of nuclide properties for the Nuclear Wallet Cards.

BNL Planned Activities

Update database as new information becomes available.

E. Decay Data Evaluation Project (DDEP)

Decay data for nuclides of importance for metrology are evaluated in an international collaboration. When complete, these evaluations are entered into the ENSDF format, and made available to ENSDF evaluators. The US Nuclear Data Program occasionally contributes to this effort on individual bases.

ANL Planned Activities

Evaluate at least one radionuclide in support of the IAEA-CRP on "Nuclear data for charged-particle monitor reactions and medical isotope production"

In collaboration with scientists from the Australian National University and under auspices of IAEA, develop new computational tools for improving data on Auger-electron emissions following radioactive decay, which are relevant to applications of medical radioisotopes

F. Neutron-Induced γ -Ray Data Evaluation

The EGAF (Evaluated Gamma-ray Activation File) database, disseminated by the IAEA and maintained by LBNL, currently provides discrete-line prompt γ -ray information from thermal (n, γ) reactions in a format tailored to suit the needs of the neutron activation analysis community. However, it requires ongoing maintenance and development to make it more useful to the applied communities it serves.

LBNL Planned Activities

Continue to maintain and develop the EGAF database. Update EGAF prompt gamma-ray cross sections from new measurements. Add activation data to the EGAF file. Include improved nuclear structure data for the RIPL library in EGAF datasets. Develop a Nuclear Data Sheet publication format for EGAF data.

Collaborate with Charles University (Prague) to perform statistical-model calculations of quasi-continuum γ -ray cascade information and generate ENDF-format capture γ -ray datasets for use with MCNP and other transport-code calculations.

Collaborate with the University of Oslo to measure low-energy photon strength functions and level densities.

LLNL Planned Activities

Evaluation of EGAF data in collaboration with LBNL

G. Evaluation of Light Nuclei for Nuclear Physics A.

TUNL evaluates additional data not included in ENSDF for publication in Nuclear Physics A and on its web site.

TUNL Planned Activities

With serious reflection that considers both the great value of the breadth of information provided in the "Energy Levels of Light Nuclei" publications and the NSDD/ENSDF network expected 7-10 year periodicity for reviews of a given nuclear mass-chain, the only feasible direction for future evaluations is to focus solely on ENSDF reviews to be published in the Nuclear Data Sheets. This follows a similar shift away from publications in Nuclear Physics A that has been made regarding the A=21-44 nuclear mass region that had previously been maintained by P. Endt and C. Van Der Leun.

H. Nuclear Structure Data Measurement

ANL, BNL, LANL and LBNL will devote a relatively small effort (a fraction of FTE each) to participate, through collaborative agreements, in nuclear physics research activities related to nuclear data needs. The emphasis will be on measurements aimed at providing answers to specific questions that arise from recent nuclear data evaluations and at improving quality of existing databases in the specific areas. These activities maintain important collaborative connections with local and national research communities.

ANL Planned Activities
Participate in nuclear physics research activities at ANL, MSU and other nuclear physics user facilities with main emphasis on decay studies of neutron-rich fission products of relevance to reactor decay heat and astrophysics applications, spectroscopy of heavy actinide nuclei and nuclei far from the line of stability
Participate in research activities using the GRETINA spectrometer and in dissemination of produced data from those activities

BNL Planned Activities
In collaboration with the Brookhaven Linear Isotope Producer (BLIP), precisely determine decay schemes of key medical isotopes using state-of-the-art gamma-ray spectroscopy.
Participate in beta-decay measurements at facilities such as Argonne's CARIBU with an emphasis on nuclei relevant to decay heat, antineutrino spectra and delayed nu-bar.
Perform precision measurements of electromagnetic transition strengths in light nuclei as a guide for improved formulations of ab-initio theories
Analyze the deep inelastic data that would be measured at ANL.

LANL Planned Activities
Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on fission-product nuclei to search for previously unobserved transitions in these nuclides. We will study neutron reactions on ^{136}Xe (with Indiana Univ) to learn more about the level structure and transitions. This nucleus is important in the search for neutrino-less double beta-decay experiments at Enriched Xenon Observatory (EXO). In addition we will study ^{186}Re and look for transitions that feed the long-lived isomer.
Interact with mass chain evaluators on the nuclear structure of these nuclei.

LBNL Planned Activities
Perform DICEBOX statistical model calculations to determine total radiative cross sections and elucidate nuclear level spins and parities.
Measure gamma ray cross sections at the Garching FRM-II and Budapest Reactors and produce improved (n,g) decay schemes and total radiative capture cross sections.
Investigate primary gamma ray photon strength functions and the contribution of the M1+E2 mixing ratio to nuclear statistical model calculations.

I. ENSDF Physics and Checking Codes

The NNDC maintains ENSDF checking and physics programs on behalf of the national and international evaluator networks.

BNL Planned Activities
Maintain and upgrade ENSDF checking and physics programs for format changes as required.
Move codes off the Lahey compiler and make compatible with gfortran.

VI. Nuclear Reaction Physics

A. Experimental Data Compilation for EXFOR

The NNDC, as part of a larger international cooperation (NRDC), has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada. NNDC concentrates on new measurements, and continues compilations of earlier publications that have not been included in the EXFOR database. Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data.

BNL Planned Activities
Compile experimental data for neutron, charged particle, and photon induced reactions from 120 publications.
Explore possibilities of recovering missing reaction data at Oak Ridge National Laboratory.

B. ENDF Evaluations

Evaluated nuclear reaction data, for applications and for basic science needs, are stored under version control software on the GForge server, which is maintained by BNL. New evaluations funded primarily from other sources are committed by LANL, LLNL and ORNL, while BNL contribution is supported by the USNDP funding. LLNL is leading international collaboration developing a new XML based data structure intended as a modern replacement for the current ENDF-6 format.

BNL Planned Activities
Respond to user needs for evaluated nuclear reaction data.
Collect and address users feedback related to the ENDF library.
Complete evaluation of ^{56}Fe in the frame of the CIELO project. Work with CSEWG on upgraded evaluations for future release of the ENDF/B library.
Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.
In collaboration with LLNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.

Provide production cross sections for medical isotopes.

LANL Planned Activities

Upgrade the LANL ENDF evaluations for U and Pu isotopes that perform well in criticality benchmarks, including new theoretical development of statistical model for deformed systems. Close collaboration with international nuclear data library activities, CIELO coordinated under OECD/NEA.

Provide upgraded ENDF evaluated data files for light and medium mass elements, including covariance data. Perform criticality benchmarks.

Provide new evaluations of the prompt fission neutron spectra for major actinides, based on the Monte Carlo technique as well as the deterministic method including pre-equilibrium emissions at high energies.

Improve photon production data for neutron capture and inelastic scattering, which will be used in prompt gamma-ray spectroscopy.

LLNL Planned Activities

Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.
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In collaboration with BNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.

C. ENDF Manuals and Documentation

The NNDC is responsible for maintaining manual of formats and procedures for the ENDF system.

BNL Planned Activities

Maintain GForge version of the ENDF-6 formats manual up-to-date with CSEWG endorsed format changes. Issue official release of the manual.

Automate the generation and posting of the latest unofficial version of the ENDF-6 formats manual.
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D. Nuclear Reaction Standards

Maintaining accurate current values for the standard cross sections is the primary objective of this task. It is efficiently accomplished through international cooperation under auspices of the IAEA.

LANL Planned Activities

Participate in the international effort to reevaluate the light-element standard cross sections with LANL leadership, and investigate the nature of output covariance data from R-matrix analyses of systems containing the light-element standard cross sections.
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Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.

We will continue the search for suitable (n,xgamma) reactions as possible reference cross sections to complement or replace the $^{56}\text{Fe}(n, \text{xgamma} = 847 \text{ keV})$ reaction, which has several experimental limitations. Targets of Fe, Cr, Ti, and Li will be studied. We work with the Institute of Reference Materials and Measurements (IRMM Belgium) in comparing their measurements with ours.
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NIST Planned Activities

Standards for the next version of a number of cross section libraries will be made available for data testing and review. These data are largely a result of work on the IAEA data development project on maintenance of the neutron cross section standards. In addition to the traditional neutron cross section standards, this includes results for the capture cross section of gold at energies below 200 keV, as well as neutron spectrum results for the spontaneous fissioning of ^{252}Cf and the fissioning of ^{235}U with thermal neutrons.
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Drafts of the work done on the standards evaluation prepared through the IAEA data development project will be prepared in electronic form.

In an effort to continually improve the standards, we continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.

Diagnostic measurements with the new deuterium gas target will be made. This work is a step in the process of detecting neutrons to measure the H(n,n) angular distribution. The measurement will lead to improved determinations at small center-of-mass angles. This work is on an experiment at 10 MeV. Data will also be obtained at 14.9 MeV in the future. This work is done in collaboration with Ohio University, LANL and the U. of Guelma.
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Data will be obtained on an experiment based on ^{252}Cf nu-bar leading to an improved calibration of NBS-I, the U.S. national primary standard neutron source and determination of our manganese bath efficiency.

Submit for publication a measurement of the $^6\text{Li}(n,t)$ standard cross section at ~ 4 meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the $^{10}\text{B}(n,\alpha)$ reaction. Continue a study of the stability of ^{10}B deposits for $^{10}\text{B}(n,\alpha)$ cross section measurements. If suitable targets can be made, cross section measurements will be initiated.

Continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. Also make these samples available for loan in physics experiments.

E. Nuclear Model Development

Nuclear reaction theory calculations have played a crucial role in the evaluation of nuclear data, and will continue to play an important part in future evaluations. USNDP develops advanced model codes to provide a state-of-the-art capability to predict reaction cross sections and to explore nuclear reaction physics in details. This task covers development and validation of nuclear reaction model codes, such as CoH and CGM (LANL), EMPIRE (BNL) and FREYA (LLNL) used for prediction of nuclear reaction observables. These codes, with parameters calibrated to reproduce available experimental data, are used to produce reaction evaluations by providing complete and consistent set of cross sections, spectra and angular distributions.

This also involves a close collaboration with experimentalists at LANSCE to interpret new measurements using the GEANIE, DANCE, and CHI-NU detectors. These data will result in advances in our understanding of nuclear reaction mechanisms, and improvements in our modeling codes.

BNL Planned Activities
Continue to improve reaction modeling in the EMPIRE code, maintain code's numerical integrity and enhance user friendly GUI.
Improve EMPIRE covariance capabilities for fast neutrons.
Maintain GForge site with the current version of the EMPIRE code.
Maintain continuous integration system ADVANCE for checking and validation of new EMPIRE versions.

LANL Planned Activities
Continue to develop a microscopic description of fission process in the fast energy range, which includes Class-I and Class-II coupling. Implement the theory into the Hauser-Feshbach code to facilitate actinide evaluations.
Apply a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets to study M1 strength function, in support of DANCE and GEANIE measurements, and fission cycle in r-process nucleo-synthesis studies.
Study neutron inelastic scattering from deformed nuclei in the fast energy range, to which theoretical calculations are essential, in collaboration with CEA, France and IAEA.
Continue prompt fission neutron and gamma-ray spectrum calculations with the Monte Carlo method to ^{235}U , ^{239}Pu , and ^{252}Cf , and compare available experimental information. Extend the neutron incident range to cover applications.
Extend the new width fluctuation correction calculation in the fast energy range to the deformed systems, based on the Gaussian Orthogonal Ensemble and the Monte Carlo technique.
Continue to develop Monte-Carlo Hauser-Feshbach code, CGM, that can be used as an event generator in radiation transport codes.

F. Nuclear Reaction Data Measurements

Experimental results are primary source of information in evaluation of nuclear data. They are also used to calibrate nuclear reaction theory calculations to interpolate or extrapolate to the regions for which no experimental data are available in order to provide complete nuclear data file. This activity is also essential to support and verify nuclear model development and application.

ANL is collaborating with INL on Measurement of Actinide Neutronic Transmutation Rates with Accelerator mass spectroscopy (MANTRA) aimed at obtaining valuable integral information about neutron cross sections on high mass actinides that are of importance to advanced nuclear fuel cycles. BNL is involved in a collaboration with BLIP to measure cross sections of relevance to the production of medical radioisotopes. LANL is traditionally involved in extensive measurement campaigns carried out at several LANL facilities at WNR such as GEANIE, FIGARO, Chi-Nu, and DANCE. Most of these activities are funded from other sources. LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal (n, γ) cross section data to supplement earlier elemental target measurements from which important information was either lacking (e.g., data from low-abundance isotopes) or discrepant.

ANL Planned Activities
Participate in nuclear data activities at ANL using the Accelerator Mass Spectrometry technique and recently irradiated actinide samples at INL

BNL planned activities
We are planning possible measurements of proton cross sections in support of isotope production at BLIP.

LANL Planned Activities
Continue to improve the techniques to measure the prompt fission-neutron spectrum for fission induced by neutrons of 0.5 to 200 MeV on ^{235}U and ^{239}Pu . The shape of the major part of the emission spectrum between 0.1 and 10 MeV will be determined in this experiment, performed in collaboration with LLNL researchers, and will be compared with the Los Alamos model prediction. The modeling includes the Monte Carlo prompt neutron emission technique and the microscopic quantum mechanical pre-equilibrium calculations. In FY16, we will conduct measurements on the portion of the fission neutron spectrum above 0.5 MeV for spontaneous fission of ^{252}Cf and neutron-induced fission of either ^{235}U or ^{239}Pu .
Study radiative strength functions in neutron capture on ^{167}Er and ^{195}Pt . The residual nuclei in their low-lying states are those characterized as a strongly deformed rotator (^{168}Er) and a transitional, gamma-soft nucleus (^{196}Pt). The gamma-ray cascades differ markedly for neutron capture in these two nuclear systems. (with Yale University and Charles University - Prague).
Complete analysis of neutron capture-to-fission cross section ratio for ^{239}Pu for neutron energies between 1 and 200 keV.
Measure the neutron capture cross-section at DANCE for at least one radioactive isotope of importance to nuclear astrophysics, probably isotopes of zinc (collaboration with Louisiana State University)
Characterize the new scintillator, CLYC, which contains Lithium, Chlorine, Cesium and Yttrium (with University of Massachusetts at Lowell). One possible use is as a neutron detector with the $^6\text{Li}(n,\alpha)$ reaction and, at higher energies, reactions on chlorine. Another is to measure the cross section of the $^6\text{Li}(n,\alpha)$ reaction.

LBNL Planned activities
Measure thermal (n, γ) cross sections using guided neutron beams in collaboration with the Budapest Research Centre and at the Munich Reactor.
Established and measure (n,n' γ) measurement capabilities at the LBNL 88" cyclotron, and the UC Berkeley neutron generator laboratory. Measure gamma ray partial cross sections.

LLNL Planned Activities
Perform surrogate (n,n'), (n,2n), (n, γ) and (n, f) measurements on several nuclei with programmatic and/or astrophysical importance. (funded from other sources)

Perform neutron capture measurements with DANCE array at LANSCE in collaboration with LANL. (funded from other sources)

G. Evaluation of Data Needed for Astrophysics

The objective of this activity is to support the nuclear data needs of the increasingly sophisticated simulations of astrophysical phenomena. ORNL chairs the Astrophysics Task Force of the USNDP, which serves to improve communication and coordination of nuclear data evaluation activities relevant for studies in astrophysics. ORNL also evaluates capture reactions on radioactive, proton-rich nuclei which are important for element synthesis and energy generation in stellar explosions. LANL participates in the USNDP effort by developing high-quality data for calculation of nucleosynthesis and makes these results available to astrophysics research community.

ANL Planned Activities

Compile and evaluate nuclear structure and decay data for neutron-rich nuclei in the fission fragments region, produced at the CARIBU facility (ANL), that are of relevance to modeling of the r-process nucleosynthesis.

Contribute to the development of the Atomic Mass Evaluation and NUBASE libraries that are scheduled for distribution in 2015
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Develop new computational tools aimed at studying the sensitivity of atomic masses and other nuclear ground state properties on the astrophysical r-process

BNL Planned Activities

Continue work neutron capture and fission integral values and their uncertainties in the energy region of interest for nuclear astrophysics.
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LANL Planned Activities

Continue improvement of neutron capture modelling for calculating neutron capture rates off-stability to s and r-process hydro-dynamics simulations. Our focus is on utilizing nuclear mean-fields theories in the nuclear reaction calculations.

Develop a method to calculate simultaneous beta-delayed neutron and fission, and provide the reaction rates for the fission cycle study in the r-process nucleo-synthesis.
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ORNL Planned Activities

Continue assessments of capture reactions on p-rich unstable nuclides that are important for novae and X-ray bursts. The nuclei to be studied are those planned for measurements at radioactive beam facilities.
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Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANCs) on nuclei near the N=82 closed shell – 81Ge, 127,129Sn, 135Te - from transfer reaction measurements on radioactive Ge, Sn, and Te nuclei. Use this information to calculate direct capture cross sections needed to model the r-process in supernovae. Develop techniques to quickly provide the nuclear structure information needed for these cross section calculations.

H. Covariances Development

Quantification of uncertainties and their correlations, mathematically represented as covariance matrices, became recently a focal point of the ENDF evaluation effort world-wide. A strong motivation for this revival is the role of covariances in guiding adjustment of the evaluations to the integral experiments to improve reliability and performance of the new libraries. Work in this field includes improvement of the methodology as well as development of actual covariance data. Major covariance activities are carried out at BNL, LANL and ORNL (the latter in the resonance region).

BNL Planned Activities

COMMARA-3, a library of covariances for the major reaction channels processed on a 33-energy grid, is to be based the reaction cross sections in ENDF/B-VII.1. Currently there is no funding for this project. Should funding be restored, the library will be reviewed and additional covariances included for the 1st Legendre moment for elastic scattering (mubar), average number of neutrons produced/fission (nubar), prompt fission neutron spectra (PFNS), and cross-material, cross-reaction covariances, where applicable. A preliminary beta version of this library was produced in FY2013 based entirely on covariance data in ENDF/B-VII.1. As time permits, additional beta releases may be possible by including processed covariances that result from integral data assimilation studies at the NNDC.
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I. Reactor Anti-neutrino and Decay Heat Calculations

Decay heat and anti-neutrino spectra can be calculated using the fission yields and decay data sublibrary from the ENDF-6 formatted libraries.

BNL Planned Activities

Improve our methods and databases to calculate anti-neutrino spectra for major actinides.

Perform decay heat calculations in collaboration with experimental groups.
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Possibly organize a workshop on the modeling of nuclear reactors antineutrino spectra.
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LANL Planned Activities

Continue assessments of continuous electron and neutrino energy spectra calculated with the Gamow-Teller strength function.

J. Verification and Validation

Quality Assurance (QA) of a nuclear data library requires that all files are checked for integral consistency and conformance with the adopted format. This part of the QA is called verification and is one of the fundamental functions of the National Nuclear Data Center. Furthermore, checking performance of the library against the integral experiments, known as validation, is an important step ensuring usefulness of the library for the

end-users. The most extensive validation is performed by LANL and other CSEWG contributors funded with non-DOE-SC sources. The USNDP supports the ultimate validation effort carried out at BNL.

BNL Planned Activities

Establish automatic, real time verification and validation of new/modified ENDF evaluations submitted to the NNDC GForge server.
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